Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

LIBRARY
RECEIVED
★ MAR 4 1940 ★
U.S. Department of Agriculture

(ACE-28)

THE USE OF REFRIGERATION IN CONNECTION WITH RESEARCH IN THE U. S. DEPARTMENT OF AGRICULTURE

By
John T. Bowen, Senior Electrical Engineer, and
W. V. Hukill, Senior Agricultural Engineer, of
The Bureau of Agricultural Chemistry and Engineering.
Presented at the meeting of the American Society of Refrigerating Engineers on January 18, 1940, at Chicago, Illinois.

A large percentage of research in the U. S. Department of Agriculture is dependent upon refrigeration, applied either directly or indirectly. Properly controlled temperatures below that of the surrounding air are essential in many investigations involving agricultural products. Humidity control is equally important to temperature control in many research problems in connection with agriculture. In addition to the use of refrigeration in actual investigational work, research laboratories in the Department are provided with cold storage space for the purpose of holding materials and specimens at the most favorable temperatures for their preservation. Some of the materials and specimens have been preserved for years and are therefore very valuable, not only because of their intrinsic value but also because of the cost of reproduction in case they should be damaged or destroyed. Hence great care is taken to insure, not only their maintenance at the proper temperature and humidity conditions but also the reliability and adaptability of the cold storage equipment.

The following descriptions of research problems were prepared largely by the investigators themselves.

BUREAU OF ANIMAL INDUSTRY

For a number of years the value of low temperature conditions in zoological research has been recognized and experiments involving various low temperatures by the Zoological Division have been used in a wide range of investigations on parasites affecting man and animals. The object of such investigations has been to ascertain those temperatures at which the vitality of the organisms is destroyed. Results of some of the tests have been incorporated in regulations with regard to meat inspection procedures and information from other tests has been used as a basis for practical control measures against parasites of livestock.

In case of parasites that occur in meat food animals and are transmissible to human beings, an extensive series of investigations on trichinae involved the subjection of pork and pork products to low temperatures. Some of the investigations involved refrigeration of infected meat at temperatures of 5° F. and higher for continuous periods of 20 to 30 or more consecutive days. Other tests involved continuous freezing of infected meat at temperatures of -10° and -20° F.; in still other tests such meat has been quickly frozen at temperatures as low as -30° or -40° F.

Investigations were conducted also to ascertain the effect of various low temperatures, some as low as 15° F. on the vitality of tapeworm cysts in beef and information obtained in the tests is applied in refrigeration of lightly infected carcasses to destroy the parasites as a practical procedure.

In the case of helminth and protozoan parasites infecting domesticated animals and not transmissible to human beings, various low temperatures are used in investigations on eggs and larval stages to ascertain the effects of such temperatures as exist in nature as well as lower temperatures on the vitality of the organisms. Information of this nature is essential to a complete understanding of life histories of the parasites and is used in the formulation of control measures that can be effectively applied to the raising of livestock nearly free of such parasites.

In studies of virus and bacterial diseases made by the Pathological Division it is necessary to subject the fresh virus or bacteria-containing tissues to prompt refrigeration up to the time that they are to be studied for the presence of infective agents. The low temperatures not only preserve the viruses or bacteria but also prevent, to a large extent, contamination by undesired organisms.

In the studies of virus diseases it becomes necessary to make frequent titrations of the virus content of a given tissue. Here again refrigeration of the material so as to prevent any loss of virus during handling is absolutely essential. As an example, we may mention the work on the virus of infectious equine encephalomyelitis. This virus is very fragile and especially sensitive to temperatures above that of ordinary refrigeration. When the titrations of this virus are made the tubes containing the various diultions must be kept at a temperature only slightly above freezing during the time that the work is being carried on. Again with the same virus it is sometimes necessary to transport virus suspensions from the laboratory in Washington, D. C. to the laboratory in Beltsville.

To maintain the virus at a constant concentration it must be kept refrigerated during transit and up to the time it is actually administered to the test animals. Although many of the pathogenic bacteria which are under experimental study are somewhat less subject to the destructive changes by high temperatures, much the same procedure must be used in studying these organisms.

In histopathological studies the diseased tissue is often taken from the body under conditions where immediate fixation is not possible. Under such circumstances the tissues must be subjected to prompt refrigeration to prevent post-mortem degenerative changes. Much valuable material would be rendered worthless for study if refrigeration were not possible.

The paraffin embedding process requires the use of ice water and the blocks of embedded tissue must be refrigerated preparatory to their sectioning by the microtome.

In certain pathological investigations the time element is of major importance and diagnostic procedures are hastened by the rapid freezing of the tissues concerned by CO_2 preparatory to sectioning for microscopic study. By this method a diagnosis may be made in an extremely short time.

Tissues, bacteria, viruses, and serums are frequently rapidly frozen by the use of certain solvents (alcohol) and dry-ice, and kept stored at very low temperatures. This is for the purpose of preserving original forms and virulence for subsequent study. The same end is achieved by quick freezing and drying under vacuum. In the dried form bacteria and viruses may be stored for long periods at ordinary

refrigerator temperature without losing their original qualities. This method of handling is of great importance in many phases of bacteriological research and has now reached commercial proportions.

Refrigeration preserves the viability of many bacteria, the infectivity of viruses, and the potency of antigens, antiserums and vaccines used in detecting or preventing many animal diseases. So does drying. The two alternatives for exceptionally prolonged preservation of rare or costly material, storage in the solidly frozen conditions, or evaporation of all the water, encounter a common practical difficulty. There is an intermediate stage in the processes of freezing or drying during which the material is subjected to the deleterious action of highly concentrated solutions of salts and organic material. Quick freezing, now made convenient by the general availability of solid carbon dioxide as a refrigerant, enables the dangerous stage during freezing to be passed through so quickly that injury is practically eliminated. Moreover, the solidly frozen material may then be directly dried without thawing. Sublimation of water vapor from the solid ice phase is readily accomplished in suitable apparatus. The essentials are an efficient evacuating air pump and an intermediate condensing trap for the evolved water vapor, commonly refrigerated by solid carbon dioxide.

The described technique for preservation of biological material is employed both by the Pathological and Biochemic Divisions.

Refrigeration is utilized in nutrition investigations of the Animal Nutrition Division as a means of maintaining constant temperatures and often humidities in general nutrition investigations with laboratory

animals such as rats, guinea pigs, and rabbits, and with farm animals, including poultry. Without such control it is impossible to obtain reproducible results in the assay of vitamins or in studies in which comparisons are being made between one type of ration and another.

For special studies of the influence of temperature on the nutritive requirements of animals, refrigerating equipment has been provided that will maintain predetermined temperatures above or below the average. Such investigations include work with poultry and small and large animals.

In studies of the effect of storage on the quality of animal products such as poultry, eggs and meat requiring refrigeration, temperatures varying from above freezing to as low as -45° F. are provided. Laboratory procedures in connection with nutrition investigations and studies of the quality of animal products require refrigeration; thus we have: A laboratory kept at 33° F. equipped with a desk, direct and alternating current, and sink; a constant temperature room for physical measurements; a constant temperature and humidity laboratory for the study of wool; and constant temperature and humidity laboratory for calorimetric investigations. Refrigeration is provided for the storage of fresh perishable material and excreta produced in nutrition investigations and is used in the preparation of biological fractions in connection with nutrition and physiological investigations.

In the work of the Animal Husbandry Division, specific temperatures within the range of -40° F. to the freezing point are being used to determine the changes effected by freezing, and by freezer storage for different

periods of time, with respect to tenderness, juiciness, rancidity, dehydration, and other factors of meat. Subfreezing temperatures are also used for the storage of meat samples until such time as they can be subjected to certain laboratory studies.

Temperatures between the freezing point and +110° F. are used in studies on chilling, ripening, curing, and the aging of cured meats, and in the storage of meat samples. The research has to do mainly with the effects of these processing factors, under different controlled-temperature conditions, on specific meat characteristics that are of concern to consumers. Such characteristics as flavor, firmness, salt distribution, and tenderness are involved.

BUREAU OF PLANT INDUSTRY

The Division of Cotton and Other Fiber Crops and Diseases of the Bureau of Plant Industry is using refrigeration and temperature control equipment in its laboratory in Washington and at the several State colleges and experiment stations, in cooperation with these institutions in much the same way that any other agency of biological research uses these facilities, mainly as small units individually-controlled by electric thermostats or other instruments - such as electric refrigerators, germinators, low temperature ovens, freezing microtomes, etc. Probably the most important special uses are low temperature germinators and air conditioning in our fiber laboratories.

Germination and early growth of seedlings are the most critical periods in the life of the cotton plant. Since cold wet weather is frequent in the spring of the year in most sections of the cotton belt,

it is necessary that we have varieties of cotton that will germinate and thrive under these conditions and produce vigorous early growth in order to get ahead of the boll weevil. Low temperature germinators are used for conducting researches along this line in laboratories at Knoxville, Tennessee and Clemson, South Carolina,

Cotton fibers are affected by changes in atmospheric temperature and humidity. In conducting fiber researches in relation to practical breeding and production problems involving accurate measurements of the length, spirality, strength, fineness, and other properties, it is necessary to have air conditioned laboratories where temperature and humidity are controlled. These are usually maintained at a temperature of 70 to 72° F. and a relative humidity of 65 percent to 70 percent.

Referring to the uses of refrigeration in the Division of Soil Microbiology, Bureau of Plant Industry, this is primarily a microbiological laboratory hence is concerned with organisms found in the soil and in the activities of those organisms in the soil.

First - storage. Any microbiological laboratory such as this must have refrigeration to maintain its stock cultures, culture media and all decomposable materials necessary for experimental work. The function of refrigeration is to slow or stop biological activity. In many cases slowing down is essential whereas stoppage means loss of cultures hence a discrimination must be made between refrigeration adapted to maintain a slow activity and refrigeration which is intended to stop as nearly as possible, without destroying.

Second, the soil in temperature regions rarely reaches high temperatures below the top 3 or 4 inches hence a large percentage of its activities are carried on within the range of 10° to 20° C. (50° to 68° F.). As a result of ages of such environment, large numbers of these microorganisms are so adapted to the lower biological range of activity that the temperatures of the warm blooded animals are deleterious if not destructive. For considerable periods during the warmer portion of the year our laboratories run as high as 30° C. (80° F.) and often higher. In order to produce conditions favorable to all of the organisms concerned and comparable to the conditions under which their activity is normally carried on, temperatures ranging from 10° to 25° C. (50° to 77° F.), as well as higher ones, are necessary. Without such control it has been necessary at times to stop all experimental work in certain lines during the summer months. With such control we find it possible to continue throughout the year, but more important than that is the fact that such temperatures allow testing under approximately natural conditions of the ranges of activity of these organisms and simulation of the environmental conditions furnished by the soil itself.

At the U. S. Sugar Plant Field Station located in Riverside, California, there is a refrigeration plant rated at 9 tons. This is used with other equipment to maintain controlled uniform conditions of the environment in a greenhouse. Experiments are conducted on curly-top, a virus disease of sugar beets which is transmitted by a small insect, the sugar-beet leaf-hopper. In the conduct of this work it has

been found desirable to reproduce the different natural environmental conditions encountered at different seasons of the year. In the greenhouse it is frequently necessary to reduce the temperature, and that is the function of the refrigerating plant.

The U. S. Sugar Plant Field Station at Houma, Louisiana, studies the general problem of inversion of sucrose in sugarcane after harvesting, that is, the deterioration of cane between the time of cutting and milling. Humidity appears to play a greater part than temperature, but temperature is important. We have a cold-storage plant at the station rated at 7 tons. Harvested sugarcane is placed in the compartments for study of the rate of inversion under different environmental conditions of temperature and humidity.

At the same station there is a small plant rated at one-half ton for use in connection with disease studies. In this case the rate of invasion of harvested sugarcane by the red-rot organism, Collectotrichum falcatum, is studied. It is routine practice to test in this manner the numerous seedling varieties developed by the sugarcane breeding project. Controlled conditions of temperature and humidity are necessary in order to make the results comparable.

A project of the Division of Sugar-Plant Investigations, namely, the study of germination and rate of growth of sugarcane varieties used as breeding material is conducted at Arlington Farm, Virginia. The project has recently been considerably enlarged to include studies of cold damage to growing plants and the effect on growing plants of temperature, humidity, and light in connection with the blooming of

sugarcane. A plant rated at 16 tons is used in connection with this work.

In addition to the plants above mentioned, we have numerous refrigerating units of domestic type used in connection with apparatus for maintaining controlled environmental conditions. These consist of a series of chambers for maintaining temperatures ranging from around 0° to 42° C. (32° to 107.6° F.). The purposes are various, but, in general, have to do with the physiological response in growth and development of micro-organisms and green plants under different environmental conditions.

The Division of Fruit and Vegetable Crops and Diseases of the Bureau of Plant Industry is conducting extensive investigations involving refrigeration. These investigations are being made in the Laboratories at the U. S. Horticultural Station, Beltsville, Maryland, and at a number of auxiliary laboratories throughout the country. The work of this Division is so varied and extensive that it is impracticable in a paper of this kind to do more than list the general headings of the research projects in which refrigeration is essential.

Influence of type of container, method of packing, and of stowage on the rate of cooling and keeping quality of fruits and vegetables held in cold storage.
Beltsville, Md.; Wenatchee, Wash.; Fresno, Calif.

Packing, precooling and transportation of peaches in the eastern states.
Beltsville, Md.

Storage of nuts.
Beltsville, Md.; Meridian, Miss.

Harvesting, packing, precooling, and transportation of strawberries.
Beltsville, Md.; Meridian, Miss.

Cold storage of fall-dug strawberry plants.
Beltsville, Md.

Packing and storage of cranberries.
Beltsville, Md.

Adaptability of different varieties of fruits and vegetables to preservation by freezing.
Meridian, Miss.

Harvesting, storage and transportation of fruits in the Pacific Northwest.
Wenatchee and Yakima, Wash.

The influence of atmospheric humidity on the keeping quality of fruits and vegetables.
Beltsville, Md.; Fresno, Calif.

CO_2 gas treatment as a supplement to or substitute for refrigeration in the transportation and storage of fruits and vegetables.
Beltsville, Md.; Orlando, Fla.; Wenatchee and Yakima, Wash.

Handling, transportation, and storage of grapes, pears, and other deciduous fruits in California.

Handling, transportation, and storage of cantaloups, asparagus, and other vegetables in California.

Precooling, storage, and transportation of citrus and other subtropical fruits in California.

Precooling, storage, and transportation of citrus and other subtropical fruits in the Gulf States.
Orlando, Florida.

Effect of cultural treatments and growing conditions on the storage and shipping quality of citrus fruit.
Orlando, Fla.

Handling and storage of dates.
Indio, Calif.

Washing, transportation, and storage of potatoes and sweetpotatoes.
Beltsville, Md.; Meridian, Miss.

Harvesting, handling, transportation, and storage of tomatoes.
Beltsville, Md.; Meridian, Mississippi.

Handling, packing, storage, and transportation of bulbs and other florists' stocks.
Beltsville, Md.; Meridian, Miss.

Storage and market diseases of fruits and vegetables.
Beltsville, Md.; New York, N.Y.; Chicago, Ill.

BUREAU OF DAIRY INDUSTRY

Application of refrigeration in the laboratories of the Bureau of Dairy Industry:

1. Control of temperatures in bacteriological investigations.

   Incubators maintained at +2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 25, 30, 32, 37.5, 40, 42, 44 and 55° C.

   a. Bacteriological investigations on the ripening of Cheddar, Swiss, Gouda, and other types of cheeses.

   b. Investigation on the symbiotic and antibiotic relations of bacteria.

   c. Investigation of the factors which control the formation, germination, and thermal death point of resistant bacterial spores.

2. Preservation of bacterial cultures by freezing and drying in a high vacuum.

3. Investigation of the effect of freezing on the physical and chemical properties of milk. This includes the possibility of preserving and transporting concentrated milk in a frozen condition.

4. Investigation of methods of preparing and holding cream in a frozen condition.

5. Investigations in the manufacture and ripening of Swiss, Cheddar, Gouda, and other types of cheese including the determination of the optimum temperature and humidity to secure the most

satisfactory development of flavor. Rooms are maintained at 34, 50, 55, 58, 60, 75, and 78° F. with humidity controlled as required.

6. Investigations on the factors which influence the physical properties, overrun, and flavor of ice cream. Utilization of a greater proportion of milk solids, not fat, in ice cream by the preparation of special milk products adapted to use in ice cream. Three types of freezers are included in the equipment and one storage room maintained at 0° F. and a laboratory at +10° F.

BUREAU OF ENTOMOLOGY
AND PLANT QUARANTINE

One of the main uses of refrigeration in entomological research work is for temperature control and air conditioning to maintain the proper temperatures and humidities for the rearing of insects. Air conditioned insectaries or facilities for growing insects are installed in various parts of the United States and are arranged to keep a relatively constant temperature and humidity with a differential of about 3° F. in temperature and 5 percent in relative humidity to furnish the optimum conditions for the rearing of various types of insects. It is of course obvious that temperature and humidity required for different types of insects will vary and the requirements therefore are not the same in the various laboratories. On the Mexican border outside temperatures of 110° F. are frequently encountered. It is therefore necessary to reduce the temperature considerably to accommodate an insect which grows best at a temperature of 80° F. and would not develop at temperatures above 100° F.

Refrigeration is also employed for the maintenance of stocks of insects for experimental work. Insects which are inactive or in aestavation at 30° F. or 40° F. may in some cases be maintained for a year or two at these temperatures and be perfectly normal when the temperature is raised to 70° F. or 80° F.

There are a large number of uses of refrigeration as a means of destroying insects. This, of course, has long been recognized as an insecticidal treatment. Its uses in the preservation of furs, furniture, etc. in cold storage are of course well known. More recently it has been shown that treatments at low temperatures by refrigeration can be employed in the destruction of larvae of certain insects in fruits and vegetables, and treatments for the Mediterranean fruit fly which specify temperatures of 34° F. or below for a period of 12 days have been found to produce 100 percent mortality in the immature stages of this insect in fruits. Grapes and other fruit are allowed entrance into this country from South Africa, where the fruit fly infestation is heavy, with assurance that no living fruit fly will be present.

FOOD AND DRUG ADMINISTRATION

One might divide the use of air conditioning for biological work into three large categories; (1) The use of air conditioned rooms for animals used in the investigation and standardization of drugs; (2) the use of air-conditioned rooms for animals used in the

investigation and assay of vitamin preparations; (3) the use of air-conditioned rooms for animals used in the general investigations in nutrition. One might well add to this a fourth use of air-conditioned space and that would be for the purpose of bacteriological investigations, serum preparations, hemotological studies, etc. In general, the purpose of air-conditioned space for animals is to maintain these animals at a relatively constant temperature and humidity, as well as for the prevention of the entrance of foreign particles in the form of dust in the air. So far as we are aware, practically all biological phenomena are modified or affected by changes in temperature, so that for investigations which must continue over a period of a year at least in a climate such as one experiences in Washington, there would be a period, especially in the summer time, when the temperature may rise so high as to greatly influence the results of experimental investigations on the living animal. This can, of course, be pointed out by several specific examples, one of which would be an attempt to assay a thyroid preparation which itself specifically affects body temperature and rate of metabolism of the animal. Unless the animals could be maintained at a relatively constant temperature, wide variations would occur in the results. The specific instances of the effect of humidity on biological phenomena in the living animal have not been so well studied but there is no question but what a variation as wide as sometimes occurs must be influential.

The removal of the fumes which arise from the excreta of the animal may likewise be a very important factor in the control of the

experimental results obtained unless these can be controlled as are best done in a room which is air conditioned by the scrubber type of machinery.

One point with regard to the air-conditioned space for laboratory experimental animals which has not been mentioned is that one likes to depend upon the colony for reproduction during the entire year. Certainly it has been demonstrated on numerous occasions that reproduction does not proceed normally and in a dependable manner when there are wide variations in temperature, and particularly when the temperature is very high.

AGRICULTURAL MARKETING SERVICE

The following is a brief description of the air conditioning systems employed in the Cotton Standardization and Associated Research Laboratories.

In dealing with various practical problems associated with cotton standardization, classification and marketing, as well as with closely related breeding and production problems and activities, measurements are needed on numerous properties of the fibers, such as: length, length variability, strength, fineness, area and shape of cross sections, cell wall development, degree of maturity or immaturity, spirality, color, porosity, rigidity, friction and drag, and viscosity. Cotton fibers are very light and fine, are hygroscopic in nature, and many of their properties vary with variations in the temperature and

especially relative humidity of the surrounding atmosphere. Therefore, since such is the case and since only accurate, precise and comparable measurements and data are adequate for the purposes and requirements, it becomes necessary for the conditioning and the testing of the samples to be done under controlled atmospheric conditions with respect to temperature, relative humidity, and air currents. Complementing and supplementing the cotton standardization and classification work, are the technical researches which consist of fiber, ginning, and spinning studies. Appropriate air conditioning installations, involving different refrigeration facilities, are in operation in the Service's laboratories in Washington and at three stations in the field.

(Washington, Fiber Laboratories). The primary requisites in these air conditioning systems are:

1. Accuracy in temperature control and relative humidity control in the cotton fiber testing laboratories. The tolerance is ± 1 percent relative humidity and ± 1° Fahrenheit.

2. Uniformity of conditions. It is desired that the temperature and relative humidity be very uniform and within the tolerance limits throughout the working area of the laboratories; that is, at least through the space of 30 inches from the floor, table height, to 60 inches above the floor at all positions within the rooms. For this reason, extreme differences in temperature anywhere in the room are very objectionable, such differences as are customarily brought about

by taking care of heat load by means of air currents. The heating load, therefore, is being taken care of by radiators which cool in the summer or when necessary, and warm as ordinary radiators when necessary during cold weather.

A sufficient quantity of fresh air for health and comfort is necessary to be brought into the room. In one instance, for example, 500 cubic feet per minute was a sufficient quantity of air for a laboratory staff of 20 persons whereas at least 2,300 cubic feet per minute would have been required if the heat load were taken care of by the air streams. At the same time, the 500 cubic feet of air may be brought into the room at a very low temperature differential whereas the 2,300 cubic feet of air must necessarily be brought in at a temperature of 10 to 15 degrees lower than the temperature of the room.

3. No air currents of any appreciable extent can be tolerated since cotton fibers are exceedingly light and easily disturbed by air currents.

4. The system must be in continuous operation for 24 hours of the day and every day of the year. The samples of cotton fibers to be treated must be allowed to remain under the atmospheric conditions to reach equilibrium before testing.

In order to get the required accuracy, the best controls, indicators and recorders for temperature and relative humidity have been employed. For the most part the controls are of the proportioning type rather than "on and off" or "overflow" type. The relative humidity is indicated and controlled directly as percentage of relative humidity rather than by independent wet and dry bulb means.

The cooling is accomplished for the most part by means of well water at 62° F., and the heating is accomplished by use of steam in heat exchangers. In two special research rooms where moisture equilibrium in cotton and total water content and rate of drying, etc., of cotton fibers is the subject of research, the range of temperature that may be maintained is from 32° F. to 100° F. and the range of relative humidity at any point of this range of temperature may be from 10 percent to 97 percent.

In these rooms, to attain temperatures below approximately 55° F., some refrigeration is required. In this case the temperature conditions in the rooms are controlled through the medium of circulation of brine through the heating and cooling coils within the room and again only sufficient air brought in for health purposes and for taking care of the humidity. The humidity load is controlled by the use of brine solution kept at a given density by the use of steam evaporating appurtenances. As the fresh air comes in, it comes to moisture equilibrium with the brine solution.

(Washington, Standardization Laboratories). In two large cotton classing rooms where cotton standards of grade of staple length and of preparation are produced and maintained, the tolerance limits in temperature are $\pm$ 2° F. and in relative humidity $\pm$ 2 percent. The Federal statutes require that standards of cotton staple lengths be accurate and an atmosphere with a temperature of 70° F. and a relative humidity of 65 percent is used as a basis and reference in this work. These cotton classing rooms have two large skylights and water flows over

these and over the roof. This water is the well water which previously has been utilized in the cotton fiber laboratories and in the cotton classing rooms for cooling or heating purposes before being conducted to the roof and skylights. This flow of water on skylights and roof takes the place of considerable insulation and of double-glazing.

(College Station, Texas, and Clemson, S. C., Cotton manufacturing, yarn, fabric, and fiber testing laboratories). In connection with the cotton quality studies, three separate air conditioning units are employed at the two spinning laboratories in cooperation with Texas A. and M. College and Clemson Agricultural College. Two of these are located at the Texas station and the third, at the South Carolina station. All are of the precision control type, with operating tolerances for temperature ± 1° F. and for relative humidity ± 1 percent. In the Texas manufacturing laboratory two levels of humidity are maintained, namely, 60 percent in the card room and 70 percent in the spinning room, with a temperature of 75° F. In the testing laboratories at both stations, in which tests are made on cotton fibers, yarn, cords, and fabrics, the so-called "standard" atmosphere is maintained, requiring a temperature of 70° F. and a relative humidity of 65 percent. All three of these systems require refrigeration of the usual type.

(Stoneville, Mississippi, Fiber testing and classification laboratories). In connection with the cotton ginning investigations conducted at Stoneville and jointly with the Bureau of Agricultural Chemistry and Engineering, use is made of precision air conditioning in the fiber testing laboratory and the cotton classing room where atmospheric

conditions of 70° F. and 65 percent relative humidity are maintained with the usual tolerances. The same general type of air conditioning and refrigeration system is used as is installed in the laboratories of the spinning project previously mentioned. The samples which represent the results of the various ginning tests pass through the fiber testing and classing laboratories where the samples are tested and examined according to routine and special procedures.

BUREAU OF AGRICULTURAL CHEMISTRY AND ENGINEERING

Constant temperature rooms at various temperature levels are maintained for the purpose of carrying on work at fixed temperatures as, for example, the determination of sugar by the polariscope and for completing operations as filtration where the crystalling material will only exist in the crystalline form at comparatively low temperatures.

Centrifuges, constant temperature baths, and other thermostatic equipment are in constant use. The centrifuges are cooled by dry ice or by separate installations of refrigerating coils. Portable refrigerating units are used in constant temperature baths. In addition, many baths with individual refrigeration equipment are being used. It is a matter of humorous comment with many of our European visitors that it is necessary for us to refrigerate constant temperature apparatus to maintain a temperature of 30° C. during our summer months.

In connection with the quick freezing of foods, commercial storage space is rented and, in addition, low temperature rooms for freezing. Three of our field laboratories are equipped with experi-

mental freezers of our own design and one of the laboratories will shortly have its own cooling and freezing storage equipment. There is in course of construction an addition to our Florida Laboratory which will have both quick freezing and frozen storage rooms.

Our work with quick freezing is concerned largely with the selection of varieties or strains of plants, such as peas, which when grown in various parts of the country will produce crops of a quality satisfactory for freezing. In addition, we are studying the effect of factors such as blanching, washing, etc., upon the quality of the frozen product. Heat transfer studies are also being carried on, but not in a very extensive engineering way.

As part of the Bankhead-Jones investigations we are studying enzymic changes which occur in food products at low temperatures, running from ordinary cold storage down to the lowest practical temperature.

The amount of research employing refrigeration in the Department of Agriculture is so extensive that it has not been practicable to include a description of all such projects, but typical ones have been mentioned. This discussion is not intended to be a report of the results of these projects. Such reports, of course, are issued from time to time by the various Bureaus.

D3288

U.S. DEPARTMENT OF AGRICULTURE
NATIONAL AGRICULTURAL LIBRARY

U.S. DEPARTMENT OF AGRICULTURE
NATIONAL AGRICULTURAL LIBRARY
UNITED STATES DEPARTMENT OF AGRICULTURE